

Reflections on my time in the Wolfe den

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ABSTRACT

The three and a half years I spent as a member of the Infrared Group were transitional. Bill Wolfe was the nexus. Bill played a role in getting me to Arizona and keeping me there. He helped me advance professionally and taught me how to think like a systems engineer. He played a central role in my effort to earn a PhD. And, he helped start me in SPIE. This paper contains my personal and honest reflections on the impact which Bill Wolfe has had on me.

Keywords: History

1. INTRODUCTION

When Mary Turner asked me to give a Wolfe Tribute talk, my first reaction was no; and, so was my second reaction. My reasons were simple. I didn't think I had anything to say. I have not followed in his footsteps. I long ago left the field of infrared and radiometry for optical testing and interferometry. I have not contributed any new knowledge or theories based on Bill's work. I have not worked my entire career with him nor do I know him well enough to shed light on his character or share any humorous stories. I have had a modest career, I am not a chief scientist or a tenured professor or a business owner or a corporate officer. And, I'm not even sure if I am officially a Bill Wolfe student. While Bill was my employer and adviser for my first three and a half years at the Optical Sciences Center, Martin Tomasko of the Lunar and Planetary Laboratory was the Principal Investigator for my project and I got my Master's degree by paying \$10 after passing my PhD preliminary examination so that I could teach introductory physics at Pima Community College – because as a new father I needed to supplement my assistantship to pay the hospital bill which was not covered by the student health plan. (Many thanks to Glenn Boreman for helping me get that job.)

But Mary persisted and asked me to think again, so I started to reflect. I thought about the person I was before first encountering Bill and I thought about the person I am today. The three and a half years I spent in the Infrared Group from 1979 to 1984 were transitional for me and Bill Wolfe was in many ways the nexus. Bill started me in SPIE. His mantra of 'Think of Everything' taught me to approach each task as a systems engineer. He helped me to advance professionally. Bill was central in my fight to be given the opportunity to earn a PhD and Fred Bartell (of the infrared group) changed my life. And, while he does not know it, Bill even played a role in getting me to Arizona.

Bill once told me that all presentations need to have three points because all sermons have three points. And, I've observed that the best sermons are those which are personal. So, with the risk of seeming narcissistic, I am going to share some very personal and honest reflections on what Bill Wolfe has meant to me as a teacher, adviser and mentor.

2. BEFORE BILL WOLFE

In my case, past is truly prologue. It is impossible to understand who I am today or how the time I spent in Bill's infrared group help shape me without knowing a little bit about who I was before my association with Bill.

I grew up on a pig farm outside of Bellevue (a small town of about 6000) in northern Ohio. To say that I was innocent or naive or ignorant about how the world worked would be an understatement. But, I made up for that deficiency by being ambitious. While I got good grades in school and thought I was smart, it seemed to me that no one else besides my parents did. As a result, I have always had a bit of an inferiority complex. In junior high school I was given a test and advised to become an accountant because I didn't have the aptitude to be a scientist or doctor or lawyer or engineer. As high school graduation approached, I was 13th out of 240 but was not elected to National Honor Society nor did I receive any academic honors. (But they made up for it in 1999 when I and my childhood friend Mark Wagner were among 14 initiated into the inaugural class of the Bellevue High School Halls of Excellence to recognize graduates who have distinguished themselves – I was the youngest inductee.) In school, I was a science/math nerd and a music geek. And to make matters worse, I was an Eagle Scout who lived in the 'country'. According to my cousin Margaret, I was a gregarious introvert. My Mom said I had the gift of gab (in junior high I had talked my way into a couple of 4H grand prizes at the county fair; I finished 3rd in a Boy Scout public speaking contest with a discourse on Einstein's pacifist beliefs; and throughout high school, as the highest ranking Boy Scout in town, for Memorial Day I recited the

Gettysburg Address at the community cemetery commemoration, for the American Legion and in church services). In middle school, each day was about survival. Fortunately, the physical intimidation stopped in 9th grade when I joined the wrestling team at the 90 pound class. There seemed to be a code that the 'popular' football and basketball players didn't pick on wrestlers – no matter how small they were. And, being a wrestler gave me a 'bravado' with which to mask my insecurities. I liked wrestling because you didn't have to rely on someone else's opinion of you to say if you were good enough or not. Either you beat the other guy or you didn't. (I did not win a single match in 9th grade, but I never gave up. And, while I never went to district or state, I won about 60% of my matches.) But best of all, my teammates always accepted me 'as-is'. I wrestled throughout high school and college. I even wrestled intramural my first year at the University of Arizona. At the same time, I also liked the camaraderie of making music. I have played in orchestras and bands (and sung in choirs) since 6th grade, including at Wittenberg and Arizona. While I long ago gave up wrestling, I still play clarinet (with my three children) in the Huntsville Twickenham Winds band. But most important of all, Karen and I met in marching band during high school – and we have been together ever since.

The only thing I did know for certain was that I was expected to go to college. My great grandfather (the son of a farmer) had gone to Oberlin College for one semester and came back to the farm with a wife. My grandfather (the son of a farmer and farm implement manufacturer) attended Oberlin for a year or two and also came back to the farm with a wife. My dad did it differently. He married mom and took her to college with him. And, after 2 years in the army, he brought her, me and his BS in Agriculture home to the farm. As I said, I was expected to go to college. But, unlike those before me, I was not expected to return to the farm. The problem, again being a complete innocent, was that I had no idea about how to go to college or in what to major. And, I received no guidance from anyone in my high school. Throughout junior high school I was selected to take standardized tests in math, science and social studies, as part of some sort of intra school competition, because I always scored in the 99% range and helped make the school 'look good'. I did similarly on the PSAT, SAT and ACT. As a result of these tests, I got lots of letters from colleges such as William and Mary, MIT, West Point and Stanford. But, I didn't know what to do with them, so I just threw them away. Finally, in February of my Senior Year, after wrestling season had ended, Dad and I took a road trip. We visited Bowling Green State University, Ohio State, Ohio Northern, and Wittenberg. At the time I was interested in physics and computers. I was interested in physics because of my high school physics teacher Mr. Meyers. I was interested in computers because for my science fair project I wanted to write a program which plotted the position of a rocket from launch to orbit. To write this program (in machine code), I had to use a mechanical stylus to punch holes into a computer card which were read by an optical scanner. I rejected Ohio State because it was too large. I rejected BGSU because the professor made me wait in the hallway for 30 minutes to talk to him for 5 minutes. And I selected Wittenberg University for two reasons. First, as I walked around campus people smiled at me. And second, the librarian there helped me find a book with the aerodynamic flight equations I needed for my rocket program. I wrote the code in the car ride back to the farm. During my freshman year at Wittenberg I thought about being a patent lawyer, but Political Science was inane (interestingly, my first son Mike majored in Political Science). I decided to major in Physics because it was the only subject which I found to be challenging and in Secondary Education because of Mr. Myers.

In hindsight, I was probably always destined to be an optical engineer. As long as I can remember, I was fascinated by cameras and photography. My first camera was a Kodak Brownie. My junior year in college I bought a Minolta XE-5 and spent a lot of time experimenting with exposure vs F/Stop, loading and developing my own film, etc. In sixth grade, I did a book report on Einstein's theory of special relativity in which I tried to explain time dilation and space contraction as a temporal Doppler effect. I still remember trying to explain the idea to my Dad as we drove back and forth to the weekly Sandusky Community Band practices. In ninth grade, for my science fair project, I tried to build a laser from a kit that I had ordered out of the back of a magazine for \$125. Dad helped me fashion a wood handle so it would look like a gun – similar to the one in the picture of Arthur Schawlow 'popping' a red balloon inside of a clear balloon. My best friend from Scouts – Mark Wagner (now a professor at the Arizona Steward Observatory) – wanted me to shoot my laser at the corner cubes on the moon through the telescope which he had built in a corn silo in his back yard. But of course, it was not a real laser. My first summer of working at Boy Scout Camp Firelands, someone donated a reflecting telescope. I was fascinated by it. I loved looking into the primary mirror, but I was never able to figure out how to use it – little did I understand that it didn't have an eye piece.

Another example of my innocence and ambition (or hubris) is when in the fall of 1977 (or winter of 1978), I wrote a letter to Wright Patterson Air Force Base, Base Commander and asked for a summer job. After a several weeks, when I didn't get a response, I called the WP main switchboard and asked for the Base Commander. After explaining the reason for my call to his secretary, she asked me to hold for a minute. In my ignorance, I was expecting the Base Commander (who was a Colonel) but what I got was the Personnel Department. They informed me that the Commander

had forwarded them my letter and that they were holding a position for me but that I had not provided them with a return address. I was given a job in the Electro-Optics Branch helping characterize the effect of atmospheric conditions on the performance of FLIR systems. My job was running the CO₂ laser and writing 8080 code to take atmospheric absorption data from a pyroelectric detector whose circuit board I drew up from a pattern, had printed by the photolithography group using a contact print and then hand soldered. I guess I did ok, because at the end of the summer, they gave me a 1040 appointment which kept me working half time for my senior year. And, I did get to meet the Colonel when one day he showed up in my lab to asking me about my summer work. I have never forgotten how it made me feel when someone important showed an interest in me. I had a similar experience a few years later when Robert Greenler visited my lab in the Annex and spent an hour asking me about my project to measure the angular scatter and linear degree of polarization of water and ammonia ice crystals. He then invited me to give a paper at his OSA Annual Meeting conference in Tucson and a conference on atmospheric optics in Lake Tahoe.

3. HOW BILL WOLFE HELPED GET ME TO ARIZONA

The first time I encountered the name William L. Wolfe was during the summer at Wright-Patterson. I was working as a Physicist's Aid to Vincent Chimelis in the Electro-Optics Group and the Infrared Handbook by William L. Wolfe was a major reference tool.



When I got back to Wittenberg, the Physics Department Chair (Dr. Hagelberg) asked to see me. He had had a summer job with the Naval Research Lab where he met someone doing optics. Dr. Hagelberg had been my Waves professor and thought that maybe I would be good at optics. He had learned that there were two optics schools in the USA. So, with his encouragement, I wrote to Rochester and Arizona; Jack Gaskill wrote back (on December 6, 1978). I applied to Arizona, Ohio State (Atmospheric Transmission group in the Electrical Engineering Department), Air Force Institute of Technology at WP, Georgia Tech (Don O'Shea and Bill Rhodes), and Colorado State University (Copper vapor laser group). I was interested CSU because my parents went there (when it was Colorado A&M) and because I had built a 'laser' for my 9th grade science fair project. (After I got to Arizona I learned that Gaskill had been at CSU at the same time as my parents, but their paths probably never crossed paths because they were in the School of Agriculture.)

I was accepted to each school EXCEPT Arizona – most to their PhD program. Karen really wanted me to go to Ohio State because that is where she was a student. And, they had offered me the most money (\$6500 for 10 months and \$3000 for the summer). But, it was in the Electrical Engineering Department and because I had a physics degree, I would have been required to take a lot of undergraduate EE classes. Georgia Tech accepted me into both the EE and Physics departments. I visited them on Thurs/Fri 5/6 April 1979. I visited Don O'Shea and Bill Rhodes. I really liked Bill's holographic data storage project. I seriously considered going to Georgia Tech, but the closest Home Economics Department for Karen was over 100 miles away at University of Georgia. So, on Tuesday April 10, I was literally typing my acceptance letter to Ohio State when Jack Gaskill called at 8 pm to tell me that 'several of their first choice candidates had declined the opportunity to attend Arizona, so they had some openings in the MS program if I was interested. BUT, he could not offer me any assistantship money.'

When I got my acceptance letter a few days later, it included the faculty picture book. And, there he was, William L. Wolfe, author of the Infrared Handbook. And, there also was Aden Meinel, author of 'Applied Solar Energy' published in 1976 on which I had written a book report for freshman composition – that book was one of the reasons I wanted to go to Arizona. I wanted to save the world with solar energy (a trait which must run in the family because on 20 Aug 2012 my daughter Sarah started her microbiology PhD for making biofuel at Miami University). Maybe it was ignorance or ambition or I just wanted to work for William L. Wolfe (or Aden Meinel), but after thinking about it (and talking with Tom Bruegge's mother, my Wittenberg professors, my Wright-Patt boss Vince Chimelis and a Wright-Patt co-worker Bill Martin who had taken classes at OSC and had been a roommate of Jim Wyant), on Fri 13 April, I turned down all the offers with money and called Gaskill accepting Arizona's offer with no guarantees. I wanted to study optics – not electrical engineering, not physics, but optics. I wanted to go to the best school possible to study with the best professors possible. Then on Easter Sunday 15 April 1979, I asked Karen to marry me – an unemployed grad student.

	WILLIAM L. WOLFE, Professor 4/5/31 Yonkers, New York Educational Background: BS, Bucknell University, 1953 MS (Physics), University of Michigan, 1956 MSE (Electrical Engineering), University of Michigan, 1966 Employment History: Research Assistant, Research Associate, Research Engineer, University of Michigan, Willow Run Laboratories, 1953-1966 Lecturer, Dearborn Campus, 1963-1966; Chief Engineer, Honeywell Radiation Center, 1966-1967; Department Manager, 1967-1969 Professor, Optical Sciences Center, University of Arizona, 1969-1976; Professor, Optical Sciences Center and College of Medicine, Department of Radiology, 1976-date. Current Research: Optical properties of infrared materials. Radiometry. Infrared target simulation. Infrared trackers. Scatter measurement and theory. Infrared imagers and scanners. Lightning sensors. Radiometry of the sun.
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4. HOW BILL WOLFE HELPED ME STAY AT ARIZONA

33 years ago, 15 August 1979, Karen and I arrived in Tucson. We were 11 days married. We had all of our worldly possessions packed in the back and on top of our new station wagon. And, we had a \$5000 government student loan on which to live. Our first day in Tucson, with the help of Norma and Kais, we found a nice apartment on Prince Road and set up housekeeping. Both my parents and my in-laws thought I was crazy – I'm not sure what Karen thought.

New student orientation was Mon 20 Aug. Some of my classmates were Glenn Boreman, Paul Hillman, Till Liepmann and Tilman Stuhlinger. Over the next 3 to 4 years, we would spend many many hours studying together. And, we and our spouses would spend an equal number of hours socializing. I would have the honor of serving as best man at Paul and Jane's wedding and getting to meet and know Paul's brother Lloyd who would become my best friend in Huntsville. Glenn would become and continues to be one of my closest friends in optics. He has always been there for me through bad and good times. Subsequent semesters would add other great friends including Dave and Sandy Chadwick.

After orientation, Jack Gaskill told me that Bill Wolfe wanted to talk with me. I interviewed with Bill on Tues 21 Aug and got a one-semester job doing some computer modeling the next day. In September (after Bernie Seraphin expressed interest in my), Bill extended my contract for the whole year. I was now an employed graduate student making \$425 per month. My fall project resulted in my first journal paper: Wolfe, William L., and Harlow P. Stahl, "Some Calculation Results using Multi-Color Radiation Inversion," *Infrared Physics*, Vol. 20, No. 5, September 1980. What I didn't know at the time was that Bill was the journal Editor. I must have done ok, because at the end of the semester, Bill gave me a longer term task working with Alan Holms on the Ammonia Crystal scattering experiment. As an aside, during the last year of this project, John Hubbs was my undergraduate research assistant.

I really liked working in the Infrared Group. Being in the Annex gave us a separate identity and a lot of autonomy. And, they were a great bunch of people. In addition to Bill Wolfe, there was Eustace Dereniak, Jim Palmer, Fred Bartell, Lang Brod (who taught me how to use the machine shop) and Jerry DeBell (with whom I had a lot of political conversations). And, while he was not in the Infrared Group or the annex, I must also acknowledge Marty Tomasko who spent hours teaching me statistical data analysis from Bevington's book. These methods for analyzing data along with the formalism of Gaskill's linear systems theory are the theoretical foundation for my entire professional career. Finally, there was Anne Damon who was Bill's secretary and acted like a surrogate mom to us graduate students. She told me all about how she used to make DeGrazia paintings and is the reason that I have one on my wall today.

Jerry told me that Bill's greatest skill was his ability to make sense out of confusing data. I witnessed this first hand several times. Bill would take my results and spread them out on his desk and look for trends, consistencies, correlations, etc. Then he would construct a story to explain the data. I would use this same technique two years later as I put together my OSA presentations and I use the same technique with my students today. I tell them not to just bring me the results, but to tell me what they think the results mean.

On the back of Bill's office door were taped nickels. He explained that they were sucker bets he had won. He explained that he never bet unless he was certain that he would win and that a nickel was small enough to entice the other person into the bet. I liked the concept and early in my career whenever I was in a disagreement with someone where I knew that I was right and wanted to terminate the discussion, I would offer to bet them a nickel. The only difference is that when I collected on the bet, I would tape the nickel to the back of their door so that they would remember the bet. But, the threat of a nickel bet only worked for those from the Infrared Group so I stopped the practice.

5. HOW BILL WOLFE HELPED ME PROFESSIONALLY

At the annual meat market which was the Optical Sciences Center Affiliates Meeting, Hughes Aircraft (and everyone else) was trolling the waters. I would like to think that they saw someone with great potential, but in reality what they saw was a Bill Wolfe student. Anyway, they hired Tilman Stuhlinger and me for the summer. I don't know how instrumental Bill was in my getting that job, but according to Mike Bafano's telephone reference, Bill said: 'He is a reasonable worker who takes a bit more direction than others to get started but once on board did well. He is very personable. And, he is best suited to do various tasks as opposed to one problem'. On Friday 16 May 1980, JPL called and offered me a summer position for \$400 per week. Then on Tues 20 May, Hughes called with a \$445 per week offer (which was also the same day that I made my first application to the PhD program). I accepted the Hughes offer and the next day (Wed May 21), Karen and I packed the car and headed to Disneyland. I started at Hughes in Culver City the following Monday. I spent the summer doing various IR system related tasks, experiments and analysis.

Bill helped me again professionally when he arranged an interview with Bob Breault on Mon 15 Nov 82. Bob had attended the presentations of my MS research about the scattering phase function and linear degree of polarization of water ice crystals at the OSA Annual Meeting in Tucson on 19 Oct 82. Also in the audience had been Bill, John Hubbs and Robert Greenler (who had invited me to speak). I gave back-to-back presentations and answered questions for another 15 minutes because the speaker behind me had cancelled. I started working for Breault Research Organization on Tues 31 May 1983 (after grading the final exams for the class I was teaching at Pima College). For the rest of my student career I supplemented my graduate assistantship doing stray-light analysis. I was the 3rd optics employee of a 5 person company. It was a great work experience. Al Greynolds said that I was one of the top 10 stray light people he knew. I have a distinct memory of, as a part of an analysis, recommending to Northrop that they should remove the top of the stray light baffle for one system because the sun was always on the bottom of the sensor and all it did was to provide a path for sunlight to get into the system. After joining BRO full time, my main infrared/radiometric accomplishment was that I designed and managed the construction of two scatterometers. The first was a CO₂/HeNe system and the second was a 5 wavelength system from Argon Ion to CO₂.

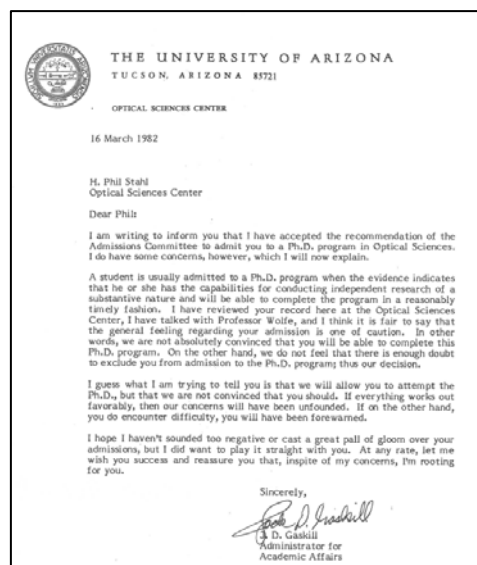
6. HOW BILL WOLFE HELPED ME GET MY PHD

My path to a PhD was long, tortuous and with many obstacles. In many regards it was one of the core struggles which has shaped me both personally and professionally. And, while over the years I had forgotten many of the more difficult details, agreeing to write this paper has allowed me to go over my journals and review the past.

Even before graduate school, when my Wittenberg quantum professor learned that I was going to apply to graduate schools he called me into his office and asked me one question: "Can you work any harder than you are right now?" When I said no, he told me to only apply for a MS because I didn't have what it took to be a PhD. His letter of reference to Arizona (which I saw in Sept 1980) questioned my intelligence and my ability to integrate knowledge between subjects. While on the subject of reference letters, Dr. Hagelberg stated that I was a late bloomer and an excellent experimentalist. And my math professor's letter cited all of my student level professional involvement, said I was an excellent public speaker and a solid upper B level theoretical mathematician. At this point I should explain that there were three of us in the physics class of 1979. Babak was clearly the best followed by myself and Dennis. Today Babak has a PhD in Solid State Physics from Ohio State and is Vice President of Quality for Intel. Dennis who dual majored in Chemistry got an MS in Physical Chemistry and does fuel cell research for DuPont.

Once I got to Arizona and started to study with my new peers, I realized that I was just as capable as they were. I got the 3rd highest grade in Dr. Barrett's E&M, I got an A in Fourier from Gaskill and an A in Shack lab. But, in a trend which would repeat itself over and over again, I got straight Bs in both of Shack's optics classes (1st and 3rd order) as well as Shannon's Optical Design class. And, while I think I got an A in every class I ever took from Wyant, I got only Bs in every class I ever took from Wolfe. There was something about lens design that I just couldn't internalize (and still cannot today), but everything about interferometry and optical testing was intuitively obvious to me. Anyway, in the fall of 1979 (18 Oct), I talked with Bill about switching to the PhD program and he was very encouraging. He said that 'If you wanted to get a PhD you should have gotten a BS from a research university like Michigan or Stanford instead of getting a BA from a school like Wittenberg'.

Regardless, on 20 May 1980 I applied for the PhD program and left Tucson for my summer job with Hughes Aircraft. On 11 Sept 1980, the Admissions Committee declined my application stating "We did not feel that your academic record, advanced GRE score, and performance in research were competitive enough". (At this point I should say that my Physics GRE had been in the mid 50% range, which was a very good score for a Wittenberg physics major, and my general had been in the 98% range). As my MS research neared its end, I applied again on 23 Feb 1982 and on 16 Mar 1982 received my 'acceptance' letter which stated: "A student is usually admitted to a Ph.D. program when the evidence indicates that he or she has the capabilities to conduct independent research of a substantive nature and will be able to complete the program in a reasonably timely fashion. ... your admission is one of caution. ... we are not absolutely convinced that you will be able to



complete this Ph.D. program. On the other hand, we do not feel that there is enough doubt to exclude you from admission ... we will allow you to attempt the Ph.D., but that we are not convinced that you should ... inspite of my concerns, I'm rooting for you." As you can imagine, I was somewhat conflicted. Bill's advice was to finish the MS and get a job. He said that I 'don't have a natural analytical nature, don't grasp the big picture, get lost on tangents, and don't go directly to root of problem' (3 May 1982). But then, while I was using a hot plate to melt indium onto the rim of my ammonia crystal glass dewar cylinder, Fred Bartell came up and said: "I've been watching you for a while, you are just as smart and talented as anyone here and I think you should get a PhD."

To be fair to Bill, he was at least partially right. I am easily distracted and can become obsessed with tangents. During the summer of 1981 I wasted a lot of time playing a dungeon and dragons type computer game. I had to decompile the code to beat the game, but once I did, I never played it again. Another reason why I was not making the progress he expected was because I was spending 10 to 15 hours per week running a Boy Scout Troop and earning my Woodbadge. But, I stopped that activity and didn't restart it until Mike joined Cub Scouts.

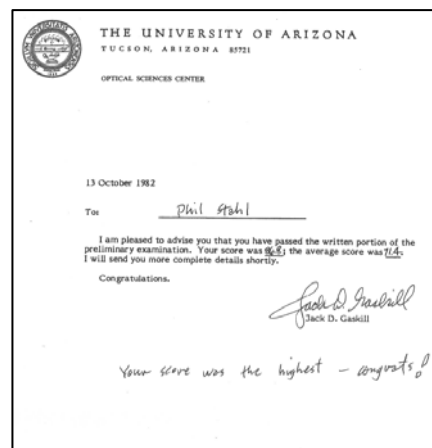
On 25 May 1982 I turned in my paperwork to switch from the MS to PhD programs. Then Karen and I left Tucson for Wilton Connecticut where I had a summer job working with Fritz Zernike at Perkin Elmer doing optical testing of model 500 microlithography machines. Because I didn't know if I would get into the PhD program and because of my academic success and ease in the laboratory with interferometry and optical testing, I wanted to try something new and was actively interviewing for a job. Dick Babish and Dave Marco courted Karen and myself during Industrial Affiliates (I loved Dick's stories about making camera lenses for the film industry and stopping in the middle of the Egyptian desert to refuel a plane and eat a sit down meal under a tent. Dick told Karen that she would make a perfect Perkin-Elmer 'girl'. And several years later, Dick told me about testing the Hubble primary mirror with a flashlight and not liking what he saw.) Anyway, I had accepted a plant trip to Perkin Elmer on 24-27 Mar without Bill's knowledge (which caused conflict). At the end of the interview process, they told me that they wanted to make me a permanent employee and that I could work for them every summer if I wanted. And, while in early May they laid off 260 engineers, Dave Marco honored his commitment and offered me a job for \$577 a week. I was the only summer employee for the entire company in 1982. Working at Perkin Elmer and for Fritz Zernike was a fantastic experience, I found my technical bliss, and started my transition from infrared/radiometry to optical testing. But I didn't leave infrared right away, my PhD dissertation was: "Infrared Phase Shifting Interferometry using a Pyroelectric Vidicon."

When I returned to Arizona at the end of the summer, even though he may have had reservations, to his great credit, Bill agreed to let me study for the Prelim Exam in the back laboratory. And, he honored that decision when others tried to claim the space. I prepared for the prelim as if I was preparing for wresting season with strenuous exercise and repetitive practice. I sequestered myself and spent the next 7 weeks studying for 8 hours a day, 6 days a week. I started by re-reading and outlining Hecht. Then I rewrote and outlined all my class notes onto 3x5 index cards. I stored these cards in my metal 'brain' and reviewed them every night before bed. And, I worked every prelim problem from the previous 5 years. Looking back now, it is interesting note the distribution of information which I had accumulated. While my Wolfe lecture notes from two classes were clearly thinner than two Shack or two Wyant classes, my note cards for all things infrared (radiometer, detectors, etc.) accounted for 37% of the total.



At the same time I took 2 classes; Karen and I took Lamaze classes; and I finished analyzing my water scatter data and prepared two presentations (per the invite from Robert Greenler) for the OSA Annual Meeting in Tucson. I fondly remember making 'blue' slides in the basement of the Lunar and Planetary Lab while listening to the Hitchhiker's Guide to the Universe on KUAZ. In the last week before the prelim exam, I prepared myself mentally to fail. I would finish the MS based on the OSA papers I was writing and would accept Perkin Elmer's offer of a permanent job. I found peace in the idea that my failure would allow others to pass.

The prelim was Tues/Wed 5/6 Oct, 1982 and I remember it vividly. Normally, I could not sit and concentrate long without a cup of coffee, so I took my place with coffee and a donut. But when told to 'begin', the world went away. All I could see was the test and my answer sheet. In four hours I did 5 problems twice (I even did one 3 times) to turn in the 4 about which I felt most confident. At the end of the first day I had not touched my coffee or donut. The second day was the same. I should say that I think Bill was trying to help me because one of the questions was about the two wavelength technique for measuring temperature which we had published together during my first semester at OSC. A week and a half later, the results were released – I got the highest score. Rich Shoemaker told me first. When I ran into Roy Frieden in the hallway and said that I was surprised, he responded with 'imagine how surprised we were'. But when Jack Gaskill gave me the notification letter he also said 'just because you passed the written does not mean that you can pass the oral'. This made me very paranoid.



The Oral was Wed 8 Dec, and I did terribly. I was generally able to answer everyone's questions except Shannon's. For some reason I simply could not understand what he was trying to ask. It seemed like he starting asking one thing and ended up asking something entirely different. In some cases, the things about which he was asking I had not yet been exposed to. And in other cases, once I understood the question, I was able to answer it. But, he didn't like that my answers tended to be mathematical. My examination lasted for 1.5 hrs and the committee deliberated for 15 min before they let me back into the room. Shannon started by stating: 'the only reason we are passing you is because you got the highest score on the written, but I certainly hope that you learn something before you graduate'. He then proceeded to take the next 20 minutes to tell me how badly I had done on the oral. He said my performance was uneven and he could not tell if I was intelligent or stupid; that I couldn't communicate my ideas clearly; and that I needed a class to teach me how all the bits and pieces of optics fit together. Angus Macleod defended me saying that all I needed was more work experience. Later Jim Palmer told me that Shannon wanted to fail me but they all thought I had done ok. Jack Gaskill's comment was that just because I had passed the prelim didn't mean that I could conduct or defend a PhD dissertation.

Bill (who was not on my committee) said the feedback he got was that I was clearly intelligent but that I didn't understand what I knew nor how to communicate it. Looking back 30 years, I agree. Even today I don't understand how I know what I know. I just know it. I have the ability to internalize knowledge and experimental setups such that they become intuitive to me. Throughout my career there are multiple examples of when I encountered a situation or had a problem presented to me that I was immediately able to see a solution when others who had been working on it for weeks or months could not. The only difference is that today I am able to explain my solution and place it into a proper context (also my track record is such that people tend to believe me). I think that teaching optics at Rose-Hulman Institute of Technology helped me (because you really don't know something until you try to teach it). But, back in 1982, I was only 25 (and would still be only 27 when I got my PhD). And, while I thought I was getting old and running out of time, I had no idea of how much I didn't know.

The really ironic thing is that nearly 1 month to the day after Shannon ripped me to shreds, I started working for him on what would become my PhD dissertation. Shannon was the Principal Investigator on an Air Force project for the ROFT program to build large optics more rapidly. Bob Parks had the idea for a swing arm generator and they needed an optical metrology tool for in-process feedback. (When Shannon became Center Director, Parks became the PI.) I was tasked to design and build an infrared phase-measuring interferometer. I don't know if I ever 'won-over' Shannon, but a few months into the project he told me that there was 'more science in my design than in most such designs'. And during a review meeting, in a response to my answer to a customer question, he quipped that 'the kid can think on his feet'.

I stayed at OSC for two more years designing, building and characterizing my infrared phase-measuring interferometer. And, I don't want to say that those two years went smoothly, because they didn't. In fact, my last year made the first three look easy, but that story has nothing to do with Bill Wolfe. What I do want to say is that I would never have gotten my PhD without the initial help of Bill Wolfe, Fred Bartell, Jim Palmer and Eustace Dereniak. And, I may not have passed the prelim if I had attempted it earlier than I did. Also, I would never have gotten my PhD without the later help of Bob Parks, Achiem Leistner (who was on sabbatical from CSIRO) and Jim Wyant.

7. HOW BILL WOLFE GOT ME STARTED IN SPIE

I attended my first SPIE meeting in San Diego 1981. It was the 25th anniversary meeting. I think that Bob Shannon had arranged for SPIE Travel Grants for a large group of us students. We stayed in dorms at UCSD and worked as AV assistants. My job was picking up and returning slides from speaker check-in; loading and unloading the slides on the projectors, etc. It was a great gig because not only did I learn the mechanics of how an SPIE meeting is run, it forced me to sit in the conference room and pay attention. I continued working AV until I graduated in 1985.

I fell in love with SPIE. I felt like I was home. It was a community of engineers and entrepreneurs who liked to socialize. This I understood. I had been President of the Wittenberg University Society of Physics Students for 2 years. My job had been to organize the annual picnic, keep the study room coffee pot full and buy beer for the weekly student faculty mixer. In high school I had been president of the science and math clubs.

In those years every SPIE registration (regardless of whether it was for a 1 day or full week) came with a banquet ticket. And, because I had worked for Hughes, I knew a lot of the people who were attending then driving back to LA. So I developed the habit of collecting banquet tickets and distributing them to my fellow students. I distinctly remember my first banquet where the speaker talked about how they did the special effects for Star Wars. I remember the 1983 banquet when Karen and I were sitting at a table in the back with 4 month old Michael when Rudolph and Helga Kingslake joined us. Helga really liked Michael. I also remember banquets in the Coronado Hotel where Jim Wyant and Roland Shack got awards.

Bill taught me two skills during my first SPIE. He taught me how to network and how to run a conference. Bill told me to walk up to him at the receptions around the Town and Country Pool and wait for him to introduce me to whomever he was speaking and answer any question which that person might ask. When that person returned to his conversation with Bill I would drift away and wait for him to start with a new person at which point I would repeat the exercise. In the conference rooms, Bill taught me about the importance of holding the speakers to the schedule and how to manage the speakers to keep them on schedule. But he always emphasized that the single most important role of the Session Chair was to make sure that every speaker got at least one question even if you had to ask that question. This rule forced me as a Session Chair to not only always pay attention to the speaker but also think about what they were saying.

8. CONCLUSIONS

In my career, I've had a lot of bosses and a handful of mentors – but only a few have been both. Furthermore, I haven't had a great track record with bosses – so it is important to acknowledge the good ones. I've had some great bosses and I've had some awful bosses. I liked my 3.5 years of working for Bill Wolfe. He was always straightforward and honest with me. He always told me the truth and most importantly he had my back. He never tried to take advantage of me. He was generous with his knowledge and ideas. And, he put my interests ahead of his. Bill and the Infrared Group profoundly affected my life. Bill slowed me up long enough to develop. And, while maybe he didn't believe that I could pass the prelim and get a PhD, he gave me the opportunity to succeed.

Today, because Bill Wolfe (and the Colonel) gave a young kid a chance, I fund several interns at NASA Marshall every year, give them meaningful tasks and publish the results. Because of Bill's mentorship, I do my best to recruit young engineers to publish at SPIE events and serve on conference committees. Because an important person like Robert Greenler (and the Colonel) spent time asking me about my work, I manage by visiting those who work for me instead of waiting for them to come to me. And, because of Bill's instruction to 'Think of Everything', I approach every problem from a 'systems' perspective.

Because of my history, I never tell anyone what they can and cannot do. Instead I tell them to actively seek their bliss and never give up until they find it. And, once they find it, to give 100% and never stop learning. I tell them that one's MS or PhD research does not need to be the best work of their career (in fact it would be very sad if it were), but that it just needs to be done. And, I take the responsibility of recommendation letters seriously. My most memorable letter was for one of my former Rose students (to whom I had given an F). He persuaded me that he had learned from his mistakes (by taking some time off then earning his BS at Purdue). I'd like to think that my letter helped him get admitted to graduate school.

But most importantly, I have been an active member of SPIE for over 33 years because of the example of those whom I admire and respect such as Bill Wolfe, Bob Parks, Jim Wyant, Bob Fischer, Jim Harvey, and many many others.